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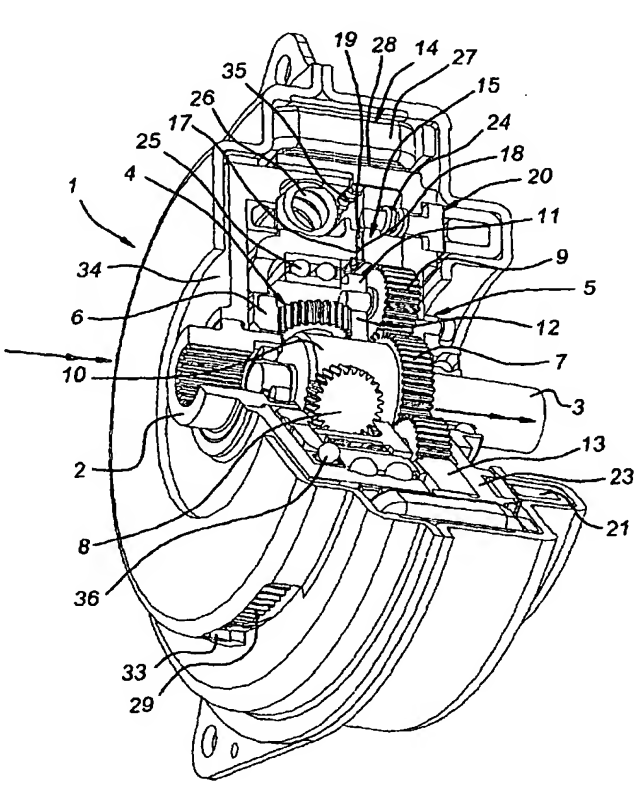


(57) Abstract: A continuously variable transmission system comprises a continuously variable transmission having two pulley sets each with two discs defining a V-shaped groove, said pulley sets being provided with a respective electrically operated actuator for varying the width of the corresponding grooves, and a clutch. An integrated starter-generator is provided and the clutch and the integrated starter-generator are carried out as a unity connected to the ingoing shaft of the continuously variable transmission. The clutch is an electromechanical gear clutch including a drive gear set (4) and a control gear set (5), each having pinion gears (8, 9), a carrier (10, 11) and a ring gear (12, 13). An electric motor (14) is used as a control means for influencing the rotation of the control gear set (5), so that drive torque can be transmitted by output shaft (3).

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# ELECTROMECHANICAL GEAR COUPLING IN A CONTINOUSLY VARIABLE TRANSMISSION SYSTEM AND CORRESPONDING CONTROL METHOD

The invention is related to a continuously variable transmission system comprising a continuously variable transmission having two pulley sets each with two discs defining a V-shaped groove, said pulley sets being connected to an ingoing shaft respectively an outgoing shaft, an endless flexible element extending between said pulley sets in the grooves thereof, said pulley sets being provided with a respective electrically operated actuator for varying the width of the corresponding grooves.

A continuously variable transmission system of this type is described in WO-A-0116507. This prior art continuously variable transmission system is a "by wire system" and has the advantage that its operation is fully electric-mechanical. Thus, no hydraulic oil is required for its control functions. As a result of this advantage, the operational flexibility of this continuously variable transmission system is greatly enhanced, and furthermore it does not pose a risk as to environmental pollution resulting from possible hydraulic oil leakages. It is pointed out that, although no hydraulic oil is applied in this prior art system for its control functions, for lubrication and cooling purposes still oil or other suitable liquid /powder substance is applied, e.g. for lubricating the actuators, the bearings of the discs and cooling the contacts/parts of the drive means and the discs.

The purpose of the present invention is to further improve said continuously variable transmission system. According to the invention this object is achieved in that at least part of a starter means is provided, and in that the clutch and the starter means or part thereof are carried out as a unity connected to the ingoing shaft of the continuously variable transmission.

The inclusion of a starter means or part thereof, which is known per se, in the continuously variable transmission system according to the invention, has several advantages. First of all, it is no longer necessary to apply additional, separate components for starting and possibly generating electric power in the drive line system. Moreover, the starter means has the well known advantage that it may also be applied for delivering additional torque boost to the drive line at well chosen instants when driving the vehicle in question, e.g. when accelerating, in city traffic etc.

The clutch must be able to convert the torque delivered by a power source, e.g. an internal combustion engine, so as to enable a smooth transition of the vehicle from

standstill to driving action. In the case of a mechanical clutch, this is obtained by making a pair of friction plates slip with respect to each other. The friction plates gradually wear down.

It is therefore preferred to provide a clutch that is of an electromechanical gear type. According to the invention there is provided an electromechanical gear clutch comprising a housing, an input shaft and an output shaft rotatably supported with respect to the housing, a drive gear set and a control gear set each comprising a first gear, a number of pinion gears, a carrier onto which the pinion gears are mounted, and a second gear, each pinion gear meshing with the corresponding first gear and second gear of the gear set, as well as control means for influencing the rotation, controlled by a sensor e.g. encoder sensor, of a first gear or a second gear of the control gear set, wherein the first gear of the drive gear set is connected to the input shaft, the carrier of said drive gear set is connected to the output shaft and the second gear of said drive gear set is connected to the carrier of the control gear set, the first gear of the control gear set being connected to the output shaft and the second gear of said control gear set being connected to the control means.

In the clutch according to the invention efficient use is made of the power which is applied for the control means which drives the control gear set. This power is added to the power generated by the engine which is to be connected to the input shaft of the clutch. Thus, at the output shaft the sum of the power fed to the control means as well as fed to the input shaft is obtained, which is beneficial when driving off or when accelerating the vehicle in question.

After the clutch has established a normal connection between the input shaft and the output shaft, that is without any rotational speed differences, the action of the control means can be stopped in case a coupling mechanism is provided for selectively establishing a rotatable or a non-rotatable connection between the input shaft and the output shaft. Said coupling means are preferably associated with the first gear of the drive gear set and the second gear of the control gear set. In particular, the first gear of the drive gear set and the second gear of the control gear set have facing surfaces which each carry a part of the coupling means, such as radially extending ridges and grooves.

With the aim of enabling the coupling action, the first gear of the drive gear set and the second gear of the control gear set are axially moveable with respect to each other for transferring said gears between a coupled and an uncoupled condition. The

coupled condition can be ascertained when the first gear of the drive gear set and the second gear of the control gear set are spring biased towards each other.

The uncoupled condition can then be obtained by means of an electromagnetic actuator for moving the first gear of the drive gear set and the second gear of the control gear set away from each other against the biasing force. The coil of the actuator is connected to the housing, and the armature thereof is connected to the electromagnetic actuator is connected to the second gear of the control gear set.

The second gear of the control gear set is supported rotatably with respect to the output shaft by means of a disc member, said second gear also being axially slidable with respect to said disc. Said disc is at the side of said the second gear facing away from the coupling means, the armature protruding through the disc and the biasing means being provided between the disc and said second gear.

The first gear of the drive gear set and the carrier of the control gear set are rotatably supported with respect to each other, e.g. by means of a rolling element bearing. Furthermore, the first gear of the drive gear set is connected to the input shaft through a spring damper.

The control means may comprise an electric motor, the stator of which is connected to the housing and the rotor of which is connected to the second gear of the control gear set.

The first gear of the drive gear set may have means, e.g. an external toothing, for engagement with a starter motor. Alternatively, the first gear of the drive gear may be connected to the rotor of a starter motor, the stator of which is connected to the housing.

The gear sets can be carried out in different forms, dependent on the lay-out of the clutch and the sizes thereof. According to a first embodiment, the first gear and the second gear of the drive gear set are face gears. Alternatively however, the control gear set is a planetary gear set, the first gear being the sun gear and the second gear being the ring gear of said planetary gear set.

All components addressed before can be included in a self contained housing, which provides the opportunity to reduce the overall space requirements for the system, and also to assemble the system in question in an efficient way into a complete drive line. This entails not only the mechanical connection of the continuously variable transmission system onto the engine bloc, but also the electric power connection and

electric control connections to the overall electric and control system of the vehicle. In this respect, the housing in question can be provided with connectors for plugging in for power supply lines, as well as further connectors for plugging in control lines, air or oil cooling pipings etc.

The versatility of the continuously variable transmission system according to the invention can be further enhanced by accommodating a forward-reverse control in the housing. This forward-reverse control can be connected to the ingoing or outgoing shaft of the continuously variable transmission. As a further possibility, a differential mechanism can be accommodated in the housing. Optionally, the forward-reverse control can be accommodated between this differential mechanism and the outgoing shaft of the continuously variable transmission.

The differential mechanism can be coupled to its pulley set through gear wheels, said differential mechanism overlapping said pulley set in such a way that the wheel shafts run parallel next to said pulley set, or are perpendicular to said pulley set.

The continuously variable transmission of the system according to the invention can be carried out in several ways. For instance the pulley sets each can have a hollow shaft accommodating a screw mechanism which is driven by an electric motor. Alternatively, the pulley sets can each have an integrated hub bearing unit which is slideable with respect to the housing. In this case, the pulley sets are driven by electric motors as well. An example of such pulley sets is described in NL-A-1019204, which is a non-prior publication.

Preferably, the drive means of the pulley sets, the forward-reverse control, the clutch and the integrated starter-generator are accommodated in a closed loop configuration with control means. Said control means is fed with signals from sensors.

For ease of manufacturing, the forward-reverse control, the clutch, the starter means and possibly integrated generator, the differential and the continuously variable transmission and control units can each be comprised in separate modules.

Furthermore, as addressed the housing may comprise an oil bath for lubricating and cooling the continuously variable transmission. Also, air cooling can be provided for particular cooling the endless flexible element.

The housing in question can consist of a single unit, or may be assembled from several sub-sections. These subhousings may be manufactured from cast iron, non metallic or composite castings or mouldings.

In order to prevent slip of the belt with respect to the pulley sets, the continuously variable transmission system according to the invention can be operated as follows:

- detecting the speed of the ingoing shaft,
- detecting the speed of the outgoing shaft,
- comparing the respective speeds of the ingoing shaft and the outgoing shaft ,
- detecting the occurrence of a difference between said respective speeds of the ingoing shaft and the outgoing shaft,
- upon the detection of a difference between said respective speeds, controlling the electro-mechanical clutch device and the electric motor in such a way that a speed difference is obtained between the input shaft and the output shaft of the electro-mechanical clutch so as to reduce the detected speed difference between the ingoing shaft and the outgoing shaft.

The invention will now be described further with reference to an embodiment shown in the figures.

Figure 1 shows a continuously variable transmission system according to the invention.

Figures 2 and 3 show view in perspective, partially in radial cross section, of a first embodiment of the clutch of figure 1.

Figure 4 shows a front view of the embodiment according to figures 2 and 3.

Figure 5 shows a radial cross section of the embodiments according to figures 2 and 3.

Figure 6 shows a view in perspective, partially in radial cross section of a second embodiment.

Figure 7 shows a front view of the embodiment of figure 6.

Figure 8 shows a radial cross section of the embodiment according to figure 6.

Figure 9 shows a third embodiment.

Figure 10 shows a power train including CVT.

The continuously variable transmission system 41 according to the invention as shown in figure 1 first of all comprises a housing 84. This housing is depicted as unity, but it may of course be assembled from several sub-sections. The housing 84 contains a continuously variable transmission having two pulley sets 43, 44 which each define a V-shaped groove 46, 47 in which an endless flexible element, e.g. a belt or chain 45 is accommodated. The pulley sets each have discs 87, 88, the mutual distance of which

can be varied by the drive means 52, 53. These drive means comprise an electric motor and a screw actuator, e.g. as described in WO-A-0116507 addressed before. The contour of the pulley discs in radial cross section which is in contact with the flexible belt or chain can be straight or curved or a combination of these shapes.

A clutch is connected to the ingoing shaft 86 of the continuously variable transmission, and will be described with reference to figures 2-5 and 9. Instead of a clutch only, also a combination 89 comprising a clutch, a starter means or part thereof and/or a generator may be applied as shown in figures 6-8.

The outgoing shaft 85 of the continuously variable transmission is connected to the forward-reverse control unit 48 which in turn through gear set 51 engages the differential 90. The differential 90 in turn is connected to the wheel drive shafts 93, which protrude from respective openings in the housing 84.

The electric motors of drive means 52, 53 of the pulley sets 46, 47, of the clutch and of the forward-reverse control 48 are all connected to a control unit 82. These connections may be fed through the housing by means of a connector which is positioned on the outside of the housing. In that case, the control unit 82 may be simply plugged in by means of an appropriate plug for connection to the connector.

The integrated starter-generator can be cooled by means of air or water. Such cooling is necessary in particular when the starter-generator is frequently used to deliver the torque boost. The electric motor of the starter-generator can be a radial or axial layout.

The forward-reverse control can also be actuated by means of an electric motor. Furthermore, more than one clutch can be accommodated in the complete drive line in which the continuously variable transmission system according to the invention has been accommodated. The clutch can also carry a separate brake disc section for accommodating a parking brake by wire arrangement.

In the foregoing reference has been made to electrically operated actuators, which can e.g. be electrical mechanic or electric magnetic actuators. All these embodiments rely on the so-called "by wire" concept.

The clutch or integrated starter-generator/clutch combination 89 will now be described further with reference to figures 2-9. The embodiment shown in the figures 2 up to 5 is related to a clutch only, and comprises a housing provided with openings from which an input shaft 2 and an output shaft 3 respectively protrude. Said output

shaft 3 of the clutch is connected to the ingoing shaft 86 of the continuously variable transmission. Furthermore, the housing 1 contains a drive gear set 4 and a control gear set 5. The drive gear set 4 consists of a first face gear 6 and a second face gear 12 which both mesh with a number of pinion gears 8. The control gear set 5 is carried out as a planetary gear set 5 having a sun gear 7, a ring gear 13 and a number of satellite gears 9.

Furthermore, control means 14 are provided which are carried out as an electric motor, the stator 27 of which is connected to the housing 1, and the rotor 28 of which is connected to the ring gear 13 of the planetary gear set 5.

The pinions 8 of the drive gear set 4 are supported by a carrier 10 which is connected to the output shaft 3. The first face gear 6 of the drive gear set 4 is connected to the input shaft 2, and the second face gear 12 of the drive gear set 4 is connected to the carrier 11 of the control gear set 5. This carrier 11 supports the satellite gears 9 of said control gear set 5. The sun gear 7 of the control gear set 5 is connected to the output shaft 3, and the ring gear 13 is connected to the rotor 28 of the electric motor 14, as mentioned above.

A coupling mechanism 15 is provided which, as shown, is in the disengaged state. This means that the input shaft 2 and the output shaft 3 are freely rotatable with respect to each other. The coupling means have facing surfaces 17 and 18, provided with ridges and grooves 19.

The surface 17 is connected to the first face gear 6 of the drive gear set 4, and the surface 18 is carried by the second or ring gear 13 of the control gear set 5. Through the toothed connecting 35, said ring gear 13 is axially moveable but non-rotatable with respect to the first face gear 6 of the drive gear set 5. By means of springs 24, the facing surfaces 17, 18 are constantly urged in engagement with each other. Furthermore, an electromagnetic actuator 20 is provided, comprising a coil 21 and an armature 22. By energizing coil 21, the armature 22 is moved against the force of the springs 24, thus bringing the facing surfaces 17, 18 out of engagement with each other.

The first face gear 6 of the drive gear set 4 and the carrier 11 of the control gear set 5 are rotatably supported with respect to each other by means of rolling element bearing 25. The first face gear 6 of the drive gear set 4 is connected to the input shaft 2 through spring dampers 26. Furthermore, the first face gear 6 of the drive gear set 4 has

an external toothing 29, which through the window 33 can engage a starter motor (not shown).

The embodiment of figures 6 up to 8 is to a large extend identical to the embodiment of figures 2 up to 5, except for the starting arrangement. As shown in figures 5 up to 8, the drive gear set 4 is now connected to the rotor 30 of a starter motor 31, the stator 32 which is connected to the housing.

The clutch according to the embodiments shown before functions as follows. In the disengaged state of the facing surfaces 17 and 18 it is after energizing coil 21, the engine onto which the clutch according to the invention is connected, is started. In the embodiment of figures 2 up to 5 this occurs by means of a starter motor engaging the toothing 29, in the embodiment of the figures 6 up to 8 this occurs by energizing the starter motor 31.

When the motor has been started, the input shaft 2 is rotating in the direction indicated by the double headed arrow in the left of figure 2. Possible shocks during starting have been damped out by the springs 26. The rotating movement is transferred from the input shaft 2, via the disc 34 connected therefore, and the springs 26 onto the first face gear 6 of the drive gear set 4. As the output shaft 3 is stationary, both the carrier 10 for the pinions as well as the sun gear 7 are stationary. This means that the face gear 6 makes the pinion gears 8 rotate about their own axes only, as a result of which the second face gear 7 and thus the carrier 11 rotates in opposite direction to the double headed arrow left in figure 2. Consequently, also the rotor 28 of the motor 14 is rotating in this opposite direction.

With the aim of making the output shaft 3 rotate in the same direction, that is according to the double headed arrow as well, the motor 14 is energized. Thereby, the rotation of the rotor 28 is slowing down, which means that the energy provided by the motor 14 provided a positive contribution to the power transferred to the output shaft 3. Thus, the output shaft 3 obtains both the power from the engine connected to the input shaft 2 as well as the power of the electromotor 14. As soon as the input shaft 2 and the output shaft 3 rotate at the same number of revolutions, also the facing teeth 17 and 18 rotate at the same speed. At that point in time, the coil 21 is de-energized whereby the grooves and ridges 19 come to grasp into each other. The input shaft 2 and output shaft 3 are now fixedly connected to each other, whereby a normal driving condition is obtained.

The embodiment of figure 9 is to a large extend similar to the former embodiments. However, in this simplified embodiment no springs 26 for damping purposes have been incorporated. The first face gear 6 of the drive gear set 4 is now directly connected to the facing surface 17 with grooves and ridges 19.

The unit, comprising a spring damper and/or a balancing unit and/or a starter motor or a starter gear can be connected to the flange 37. A balancing unit 36, known per se, is connected to the disc 34 for balancing the complete arrangement. The electric motor 14 can act as a booster, not only upon clutching but also during normal driving conditions with the clutch fully engaged. Also the starter motor 31 of the embodiment according to figures 6-8 can act as such a booster.

The unit can furthermore be used to prevent slip of the flexible member 45 with respect to the pulley sets 43, 44. As soon as such slip would occur, for instance by detecting the speed of the ingoing shaft 46 and of the outgoing shaft 45, the electric motor 13 is controlled in such a way that a speed difference is obtained between the ingoing rotation member 2 and the outgoing rotation member 3 so as to reduce the detected speed difference between the ingoing shaft 46 and the outgoing shaft 45, thereby reducing or avoiding slip of the flexible element 45. This can also be achieved by:

- providing engine map data related to the engine torque as a function of engine speed and engine throttle opening,
- measuring the engine speed and the engine throttle opening,
- determining the engine torque on the basis of the aforementioned measurements,
- selecting a clutch slip torque which is higher than the calculated engine torque, and which is lower than the belt slip torque of the continuously variable transmission.

According to a further possibility, both electric motors can be driven simultaneously for providing a torque boost with the aim of accelerating or decelerating the vehicle, either from a stand still position (forward or reverse) or during driving conditions.

The electric motors 14 and 31 can also simultaneously act as generators. The supporting bearings addressed before can be carried out as rolling element bearings, plain bearings or a combination thereof. Bearings can be lubricated and sealed for life. The outgoing member may alternatively be carried out with an external mechanical

connection means for connection to the transmission. These means can be slideable, and can e.g. be constituted by splines.

The clutch components can be made of metallic, non-metallic or composite material. The components can be manufactured by means of cold-forming, stamping of sheet metal, turning, milling, casting, moulding, and also by means of joining methods such as welding and glueing. The gears can be spur gears, helical gears or face gears. They can be lubricated with e.g. grease. The electric motors can be of a permanent magnet type or of a brush type. They are concentric with respect to the axis of the clutch.

The forward-reverse shifting system can be of a built-on, integrated by wire type. Also, a built-on, integrated by wire parking brake system can be included, e.g. of a brake disc type (friction) or of a mechanical clamping type.

The clutch can be applied for automotive and industrial application. Also application in both manual and automatic transmissions is possible. The clutch may form an integrated part of a self-contained complete continuously variable transmission by wire incorporating a continuously variable transmission by wire, a clutch by wire, forward-reverse control by wire, parking brake by wire.

The clutch by wire and integrated starter-generator concerns a so-called "medium" or "mild" hybrid transmission. In this driveline concept the electric motor(s) supply only a short boost torque at any driving condition. In a so-called "full" hybrid transmission, the electric motor(s) drive the vehicle from a standstill position to a defined speed, after which the electric motor is switched off. The vehicle power propulsion is then taken over by a relative small internal combustion engine. The electric motors as described earlier then consist of a small electric motor to start up the internal combustion engine, and a big electric motor to drive the vehicle as described above. For both types of transmissions, the electric motor(s) can consist of a permanent magnet type or a brush type, with the rotor concentric or right angle towards the centerline of the clutch. When the rotation direction of the electric motor is switched in opposite direction, then a reverse driving mode for the vehicle will be established.

The combination 89 comprising a clutch with or without integrated starter-generator as described as part of an integrated CVT by wire system, can also be applied with an additional clutch 92 behind said clutch or combination 89 of the CVT by wire transmission, see figure 10. This figure 10 also shows the engine 90, CVT 43, 44 and

drive axle 91 of a vehicle. This so-called double clutch configuration provides the option to maintain the torque capabilities whenever the CVT is "changing speed" in steps. In general automotive and industrial applications can be considered, e.g. CVT, automatic-manual transmission with ISG and hybrid power trains.

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**CLAIMS**

1. Continuously variable transmission system (41), comprising a continuously variable transmission having two pulley sets (43, 44) each with two discs (87, 88) defining a V-shaped groove (46, 47), said pulley sets (43, 44) being connected to an ingoing shaft (86) respectively an outgoing shaft (85), an endless flexible element (45) extending between said pulley sets (43, 44) in the grooves (46, 47) thereof, said pulley sets (43, 44) being provided with a respective electrically operated actuator (52, 53) for varying the width of the corresponding grooves (46, 47), and a clutch, characterized in that at least part of a starter means (29, 31) is provided, and in that the clutch and the starter means or part thereof are carried out as a unity (89) connected to the ingoing shaft (86) of the continuously variable transmission.

2. Continuously variable transmission system according to claim 1, wherein the clutch is an electromechanical gear clutch, comprising a housing (1), an input shaft (2) and an output shaft (3) rotatably supported with respect to the housing (1), a drive gear set (4) and a control gear set (5) each comprising a first gear (6, 7), a number of pinion gears (8, 9), a carrier (10, 11) onto which the pinion gears (8, 9) are mounted, and a second gear (12, 13), each pinion gear (8, 9) meshing with the corresponding first gear (6, 7) and second gear (12, 13) of the gear set (4, 5), as well as control means (14) for influencing the rotation of a first gear (7) or a second gear (13) of the control gear set, wherein the first gear (6) of the drive gear set (4) is connected to the input shaft (2), the carrier (10) of said drive gear set (4) is connected to the output shaft (3) and the second gear (12) of said drive gear set (4) is connected to the carrier (11) of the control gear set (5), the first gear (7) of the control gear set (5) being connected to the output shaft (3)and the second gear (13) of said control gear set (5) being connected to the control means (4).

3. Continuously variable transmission system according to claim 2, wherein a coupling mechanism (15) is provided for selectively establishing a rotatable or a non-rotatable connection between the input shaft (2) and the output shaft (3).

4. Continuously variable transmission system according to claim 3, wherein the coupling means (15) are associated with the first gear (6) of the drive gear set (4) and the second gear (13) of the control gear set (5).

5. Continuously variable transmission system according to claim 4, wherein the first gear (6) of the drive gear set (4) and the second gear (13) of the control gear set (5) have facing surfaces (17, 18) which each carry a part of the coupling means (15).

6. Continuously variable transmission system according to claim 5, wherein the coupling means (15) comprise radially extending ridges and grooves (19).

7. Continuously variable transmission system according to claim 4, 5 or 6, wherein the first gear (6) of the drive gear set (4) and the second gear (13) of the control gear set (5) are axially moveable with respect to each other for transferring said gears (6, 13) between a coupled and an uncoupled condition.

8. Continuously variable transmission system according to claim 7, wherein the first gear (6) of the drive gear set (4) and the second gear (13) of the control gear set (5) are spring biased towards each other.

9. Continuously variable transmission system according to claim 8, wherein an electromagnetic actuator (20) is provided for moving the first gear (6) of the drive gear set (4) and the second gear (13) of the control gear set (5) away from each other against the biasing force.

10. Continuously variable transmission system according to claim 9, wherein the coil (21) of the the actuator (20) is connected to the housing (1), and the armature (22) thereof is connected to the second gear (13) of the control gear set (5).

11. Continuously variable transmission system according to claim 10, wherein the second gear (13) of the control gear set (5) is supported rotatably with respect to the output shaft by means of a disc member (23), said second gear (13) also being axially slidable with respect to said disc member (23).

12. Continuously variable transmission system according to claim 11, wherein the disc member (23) is positioned at the side of said the second gear (13) facing away from the coupling means (15), the armature (22) protruding through the disc member (23) and the biasing means (24) being provided between the disc member (23) and said second gear (13).

13. Continuously variable transmission system according to any of the claims 2-12, wherein the first gear (6) of the drive gear set (4) and the carrier (11) of the control gear set (5) are rotatably supported with respect to each other, e.g. by means of a rolling element bearing (25).

14. Continuously variable transmission system according to any of the claims 2-13, wherein the first gear (6) of the drive gear set (4) is connected to the input shaft (2) through a spring damper (26).

15. Continuously variable transmission system according to any of the claims 2-14, wherein the control means (14) comprise an electric motor, the stator (27) of which is connected to the housing (1) and the rotor (28) of which is connected to the second gear (13) of the control gear set (5).

16. Continuously variable transmission system according to any of the claims 2-15, wherein the first gear (6) of the drive gear set (4) has means, e.g. an external toothing (29), for engagement with a starter motor.

17. Continuously variable transmission system according to any of claims 2-15, wherein the first gear (6) of the drive gear (4) is connected to the rotor (30) of a starter motor (31), the stator (32) of which is connected to the housing (1).

18. Continuously variable transmission system according to any of the claims 2-17, wherein the first gear (6) and the second gear (12) of the drive gear set (4) are face gears.

19. Continuously variable transmission system according to any of the claims 2-18, wherein the control gear set (5) is a planetary gear set, the first gear being the sun gear (7) and the second gear being the ring gear (13) of said planetary gear set (5).

20. Continuously variable transmission system according to any of the preceding claims, wherein a forward-reverse control (48) is provided.

21. Continuously variable transmission system according to claim 20, wherein the forward-reverse control (48) is connected to the ingoing shaft (86) or outgoing shaft (85) of the continuously variable transmission.

22. Continuously variable transmission system according to any of the preceding claims, wherein a differential mechanism (50) is provided.

23. Continuously variable transmission system according to claim 21 and 22, wherein the forward-reverse control (48) is accommodated between the outgoing shaft of the continuously variable transmission (85) and the differential mechanism (50).

24. Continuously variable transmission system according to claim 23, wherein the differential mechanism (50) is coupled to its pulley set (44) through gear wheels (51), said differential mechanism (50) overlapping said pulley set (44) in such a way that the wheel shafts (93) run parallel next to said pulley set (44), or are perpendicular to said pulley set (44).

25. Continuously variable transmission system according to any of the preceding claims, wherein the pulley sets (43, 44) each have a hollow shaft accommodating a screw mechanism which is driven by an electric motor.

26. Continuously variable transmission system according to any of the preceding claims, wherein the pulley sets (43, 44) each are integrated with a pulley hub bearing unit which is slidable with respect to the housing.

27. Continuously variable transmission system according to any of claims 1-25, wherein the pulley sets (43, 44) are supported with respect to the housing by means of bearings which allow rotations as well as axial displacements.

28. Continuously variable transmission system according to any of the preceding claims, wherein control means (82) are provided for controlling the drive means (52, 53) of the pulley sets (43, 44), the forward-reverse control (48) and the clutch and the starter means (31) or part (29) thereof.

29. Continuously variable transmission system according to claim 28, wherein drive means (52, 53) of the pulley sets (43, 44), the forward-reverse control (48) and the clutch and the starter means (31) or part (29) thereof are in a closed loop configuration with the control means (82).

30. Continuously variable transmission system according to any of the preceding claims, wherein the forward-reverse control, the clutch, the continuously variable transmission and the differential are each comprised in separate modules.

31. Continuously variable transmission system according to any of the preceding claims, wherein the belt is a push belt or a pull chain or belt of metallic and/or non-metallic components.

32. Continuously variable transmission system according to any of the preceding claims, wherein the housing (84) comprises an oil bath for lubricating and cooling the continuously variable transmission.

33. Continuously variable transmission system according to any of the preceding claims, wherein air cooling is provided for cooling the endless flexible element (45).

34. Continuously variable transmission system according to any of the preceding claims, wherein the housing (84) is assembled from several subsections.

35. Continuously variable transmission system according to any of the preceding claims, wherein the housing (84) is provided with at least one connector for power supply to the electro-mechanical actuators, at least one connector for controlling said actuators, and pipings and nozzles for oil and/or air cooling purposes of the flexible drive means.

36. Method for operating the continuously variable transmission system according to any of claims 9-12, comprising the steps of:

- detecting the speed of the ingoing shaft (86),
- detecting the speed of the outgoing shaft (85),
- comparing the respective speeds of the ingoing shaft (86) and the outgoing shaft (85),
- detecting the occurrence of a difference between said respective speeds of the ingoing shaft (86) and the outgoing shaft (85),
- upon the detection of a difference between said respective speeds, controlling the electromagnetic actuator (20) and the electric motor (14) in such a way that a speed difference is obtained between the input shaft (2) and the output shaft (3) so as to reduce the detected speed difference between the ingoing shaft (86) and the outgoing shaft (85).

37. Method according to claim 36, comprising the step of controlling the electromagnetic actuator (20) and the electric motor (14) in such a way that the detected speed difference between the ingoing shaft (86) and the outgoing shaft (85) is essentially zero.

38. Power train comprising a continuously variable transmission system (43, 44) according to any of claims 1-35, wherein the transmission (43, 44) is electrically actuated.

39. Power train according to claim 38, wherein a double clutch system (89, 92) is applied.

40. Method for operating a power train comprising the continuously variable transmission system (43, 44) according to any of claims 1-35, as well as an internal combustion engine (90) connected to said continuously variable transmission system (43, 44), comprising the steps of:

- providing engine map data related to the engine torque as a function of engine speed and engine throttle opening,

- measuring the engine speed and the engine throttle opening,

- determining the engine torque on the basis of the aforementioned measurements,

- selecting a clutch slip torque which is higher than the calculated engine torque, and which is lower than the belt slip torque of the continuously variable transmission.

Fig 1

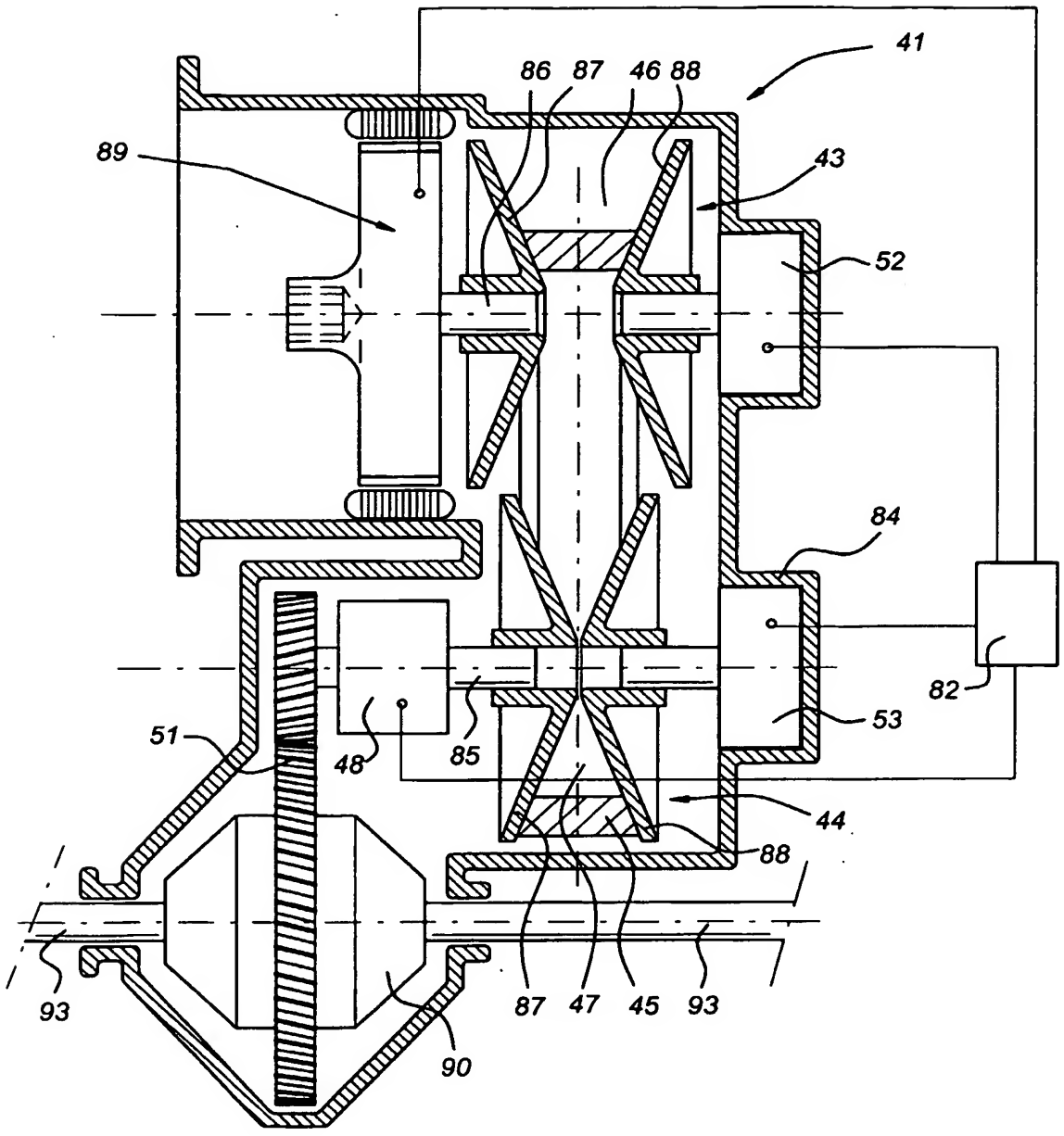

Fig 3

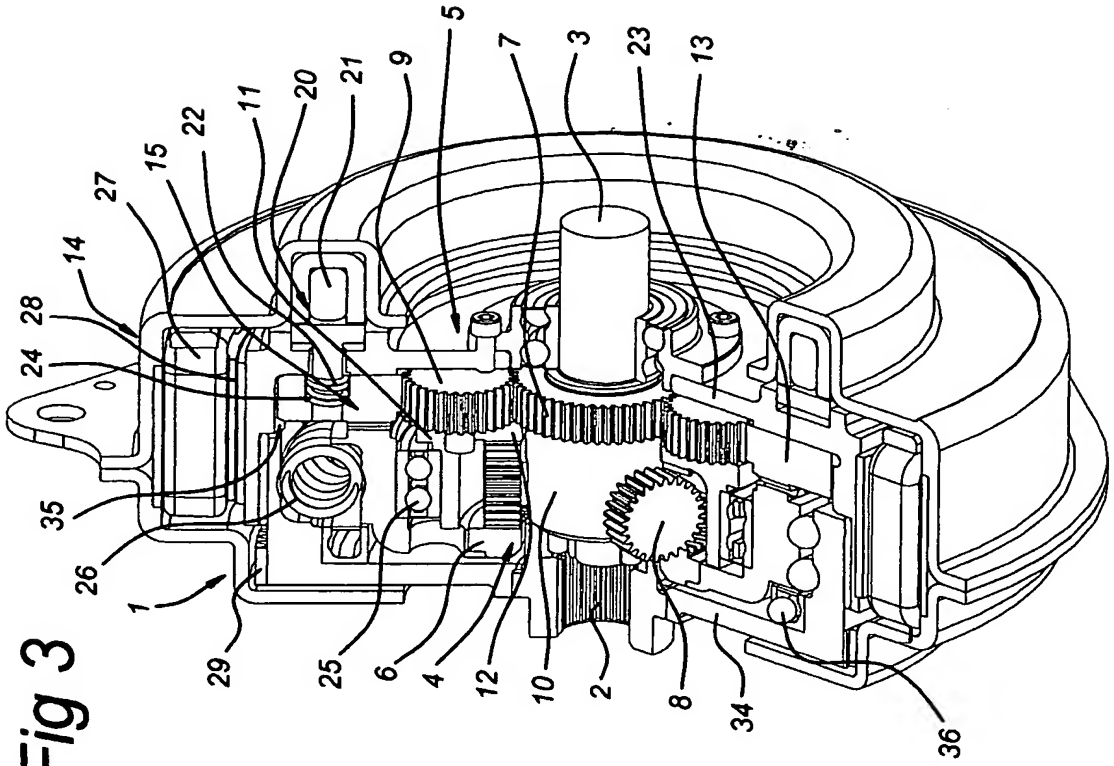
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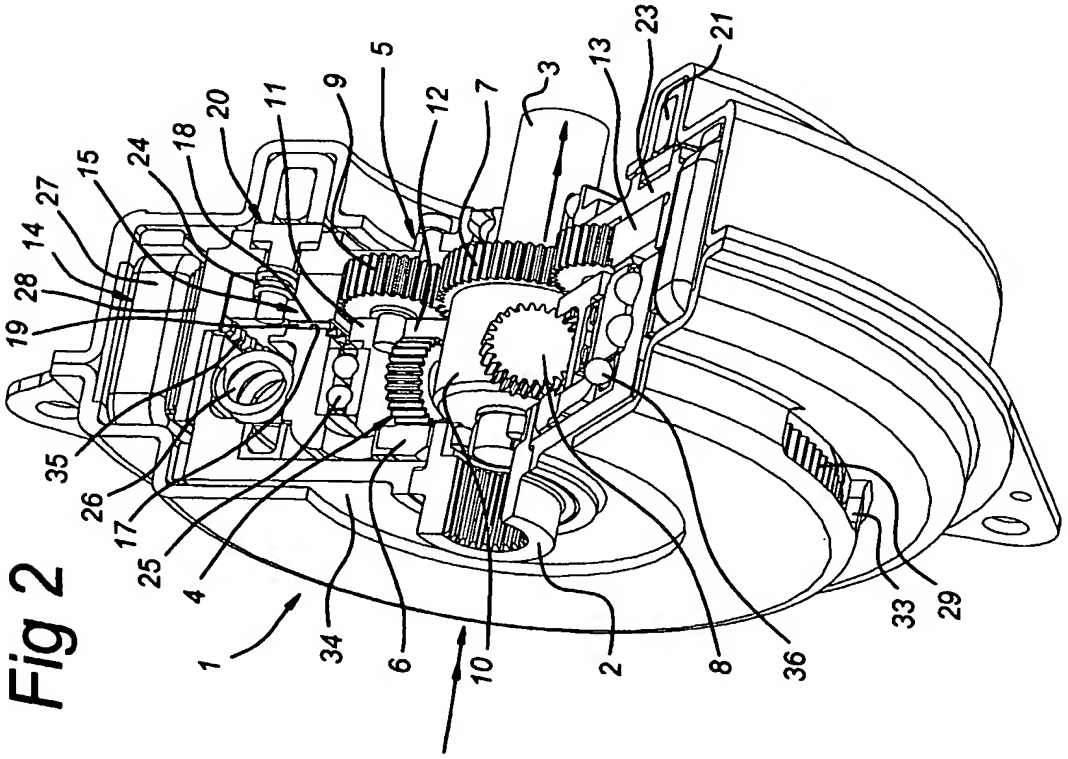
Fig 2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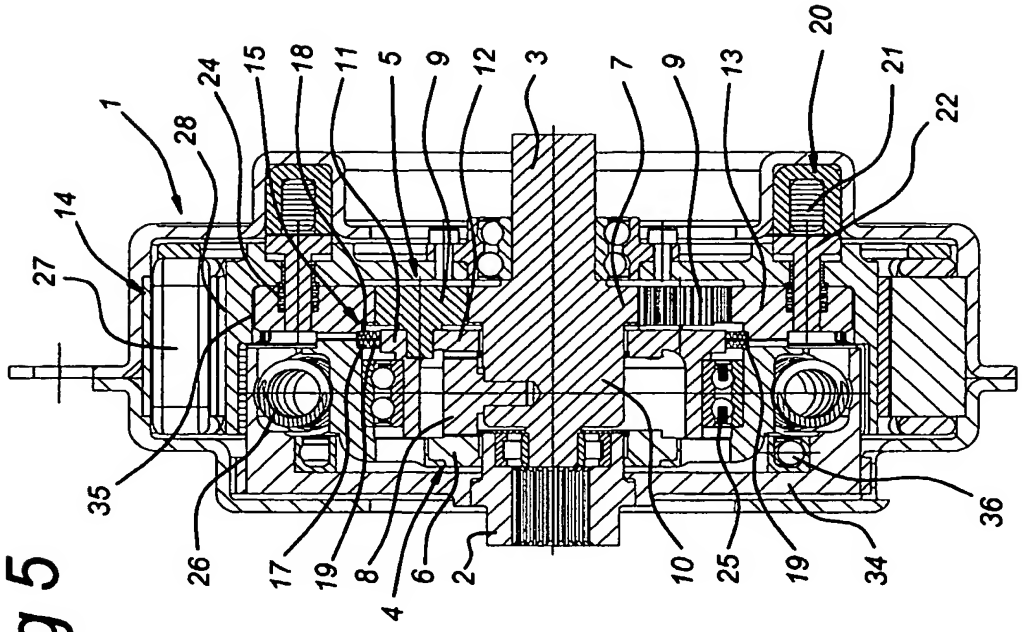
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Fig 5

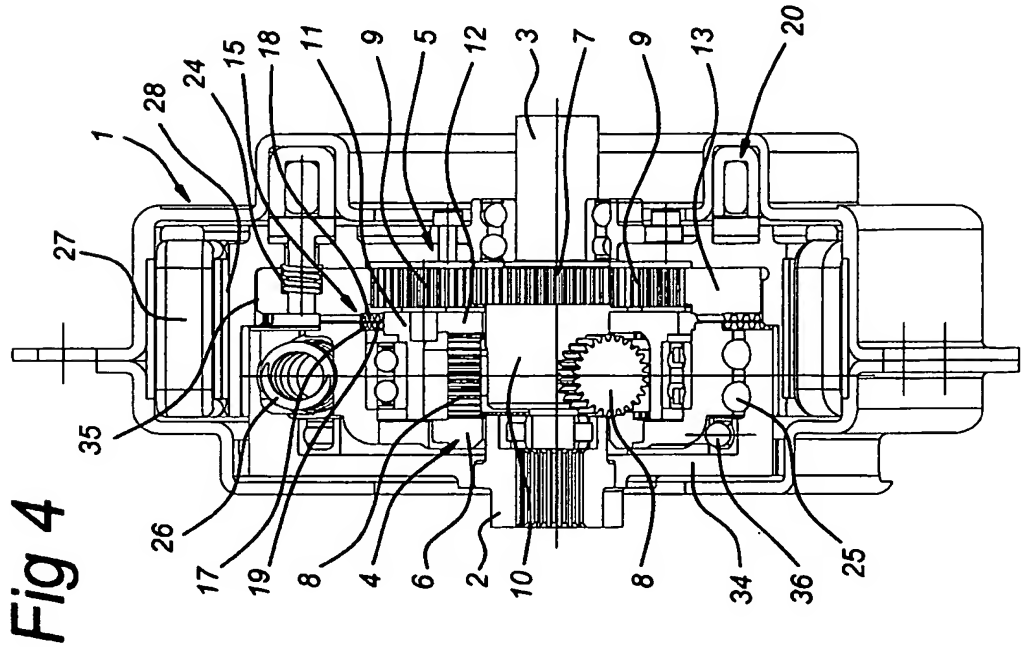
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Fig 4

Fig 8

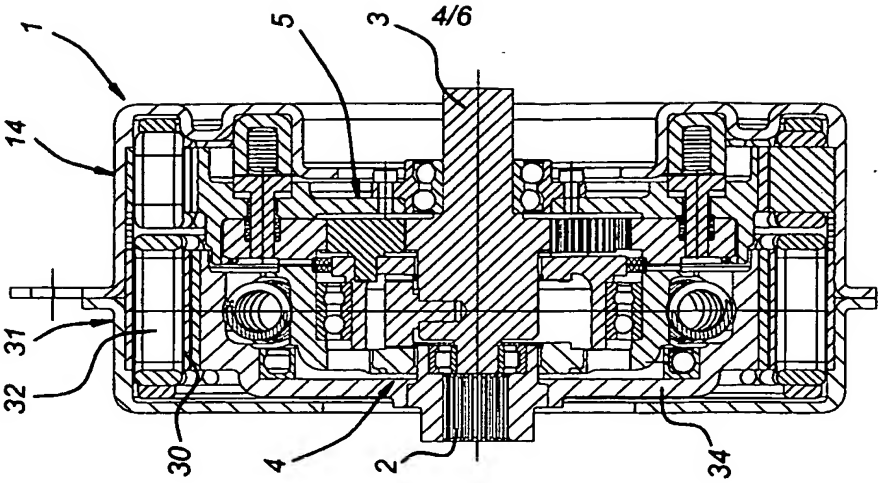



Fig7

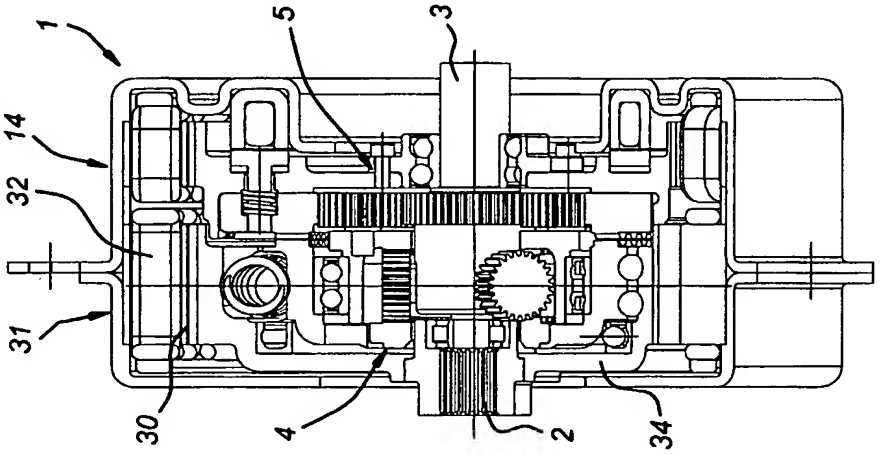



Fig 6

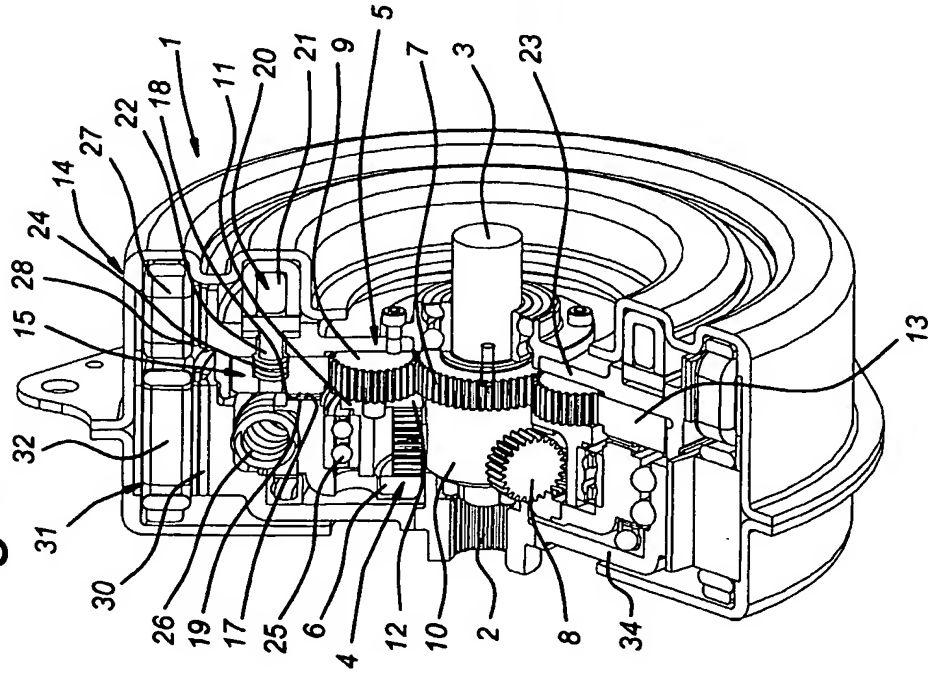


Fig 9

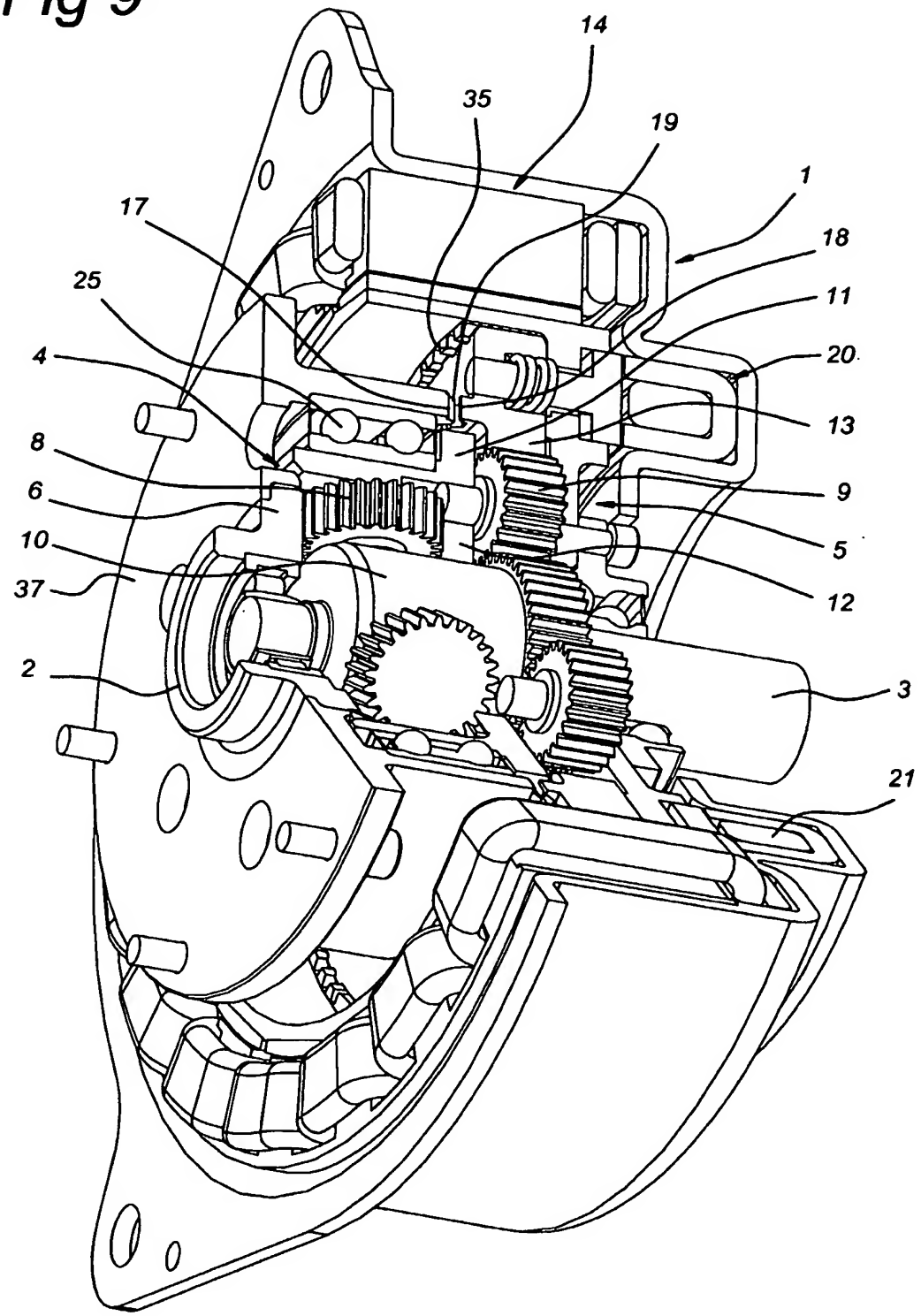
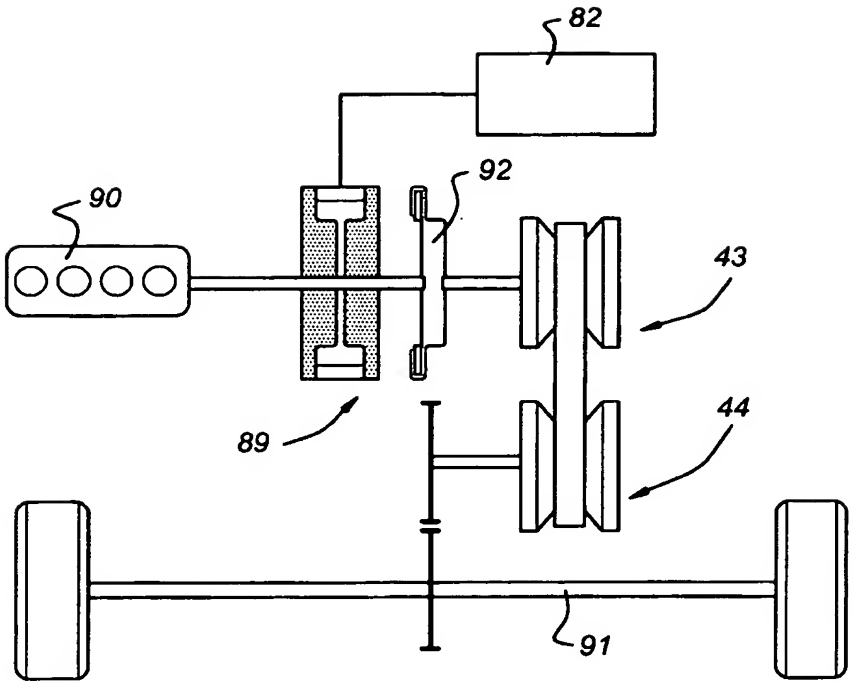


Fig 10



# INTERNATIONAL SEARCH REPORT

Inte onal Application No
PCT/NL 03/00273

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16H3/72 B60K6/04 H02K7/116 F16D27/118 H02K7/108
F02N15/04 F02N11/04 F16H61/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16H B60K F16D F02N H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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| European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016 | Bufacchi, B |

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national application No.
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# INTERNATIONAL SEARCH REPORT

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
*because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).*

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-39

   Arrangement of clutch and starter means in continuously variable transmission, and method operating such arrangement.

2. Claim : 40

   Method for selecting clutch slip torque while operating a continuously variable transmission

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